Lec 8 — Heat transfer — 29/4/2015

Chapter 4
Natural Convection

$q = hA\Delta T$

$Nu = f[Ra]$ → Rayigh No.

$Ra = Gr \cdot Pr$

$Nu = \frac{hL_c}{k}$

$Gr = \frac{g\beta\Delta T L_c}{\nu^2}$

$Pr = \frac{\mu c_p}{k} = \frac{\rho \nu c_p}{k}$

$Nu = [\quad][Gr \cdot Pr]^{[\quad]}$ (Ra)

Chapter 5
Forced Convection

$q = hA\Delta T$

$Nu = f[Re]$ → Peclet No

$Pe = Re \cdot Pr$

$Nu = \frac{hL_c}{k}$

$Re = \frac{\rho V L_c}{\mu} = \frac{VL_c}{\nu}$ (V: velocity [m/s]) ⇒ [Reynold No]

$Pr = \frac{\mu c_p}{k} = \frac{\rho \nu c_p}{k}$

$Nu = [\quad][Re \cdot Pr]^{[\quad]}$ (Pe)

$\dot{m} = \rho VA = \rho V \frac{\pi}{4} D^2$

* for sphere & tube (cylinder)

$L_C = D$

* for plate

$L_C = H$ ⇒ vertical

$L_C = W$ ⇒ horizontal

1- Sheet 5

* Properties of Air

$Pr = 0.7$

$\nu = 18.97 \times 10^{-6}\ m^2/s$

$k = 0.1025\ w/mk$

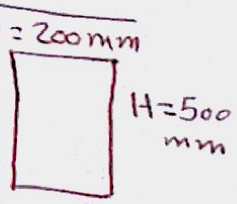
$Nu = 0.1664 [Re]^{1/2} [Pr]^{1/3}$

Given: $V = 2\ m/s$, $T_{air} = 20°C$, $t_s = 100°C$

Required: $q = ?$

1) $L_C = H = 0.5\ m$

2) $L_C = W = 0.2\ m$



$A = HW$

Solution: 1) $Pr = 0.7$

$Re = \frac{VL_c}{\nu} = \frac{2 * 0.5}{18.97 * 10^{-6}} = [\quad]$

$Nu = 0.1664 [Re]^{1/2} [Pr]^{1/3}$

$\frac{hH}{k} = [\quad] \Rightarrow h = [\quad]\ w/m^2k$

$q = hA\Delta T = [\quad]$ Watt

2) $Pr = 0.7$, $L_c = W = 0.2\ m$

$Re = \frac{VL_c}{\nu} = \frac{2 * 0.2}{18.97 * 10^{-6}} = [\quad]$

$Nu = 0.1664 [Re]^{1/2} [Pr]^{1/3}$

$\frac{hW}{k} = [\quad] \Rightarrow h = [\quad]\ w/m^2k$

$q = hA\Delta T = [\quad]$ Watt

[2] - sheet [5] (Important)

Properties of Air

$C_p = 1008\ J/kg\cdot k$

$k = 0,0286\ w/mk$

$\rho = 1,076\ kg/m^3$

$\mu = 19,8 * 10^{-6}\ kg/m\cdot s$

$Nu = 0,664 [Re]^{1/2} [Pr]^{1/3}$

$\frac{hLc}{k} = 0,664 \left[\frac{\rho V Lc}{\mu}\right]^{1/2} \left[\frac{\mu Cp}{k}\right]$

Given:

$A = 1\ m^2$

thickness = 3mm

$= 3 * 10^{-3}\ m$

$ts = 90°C$

$Tair = 20°C$

$V = 2\ m/s$

$\rho_{glass} = 2500\ kg/m^3$

$C_{p_g} = 670\ J/kg\ k$

Required: Rate of change (ΔT) $\Rightarrow$ [°c/s] or [k/s]

Solution:

$\hookrightarrow h = [\ ]\ w/m^2k$

$q_r = h(2A)\Delta T = [\ ]$ watt

(2A: Both Sides)

$\because \rho_{glass} = \frac{m}{Vol} = \frac{m}{Area(A) * thickness} \Rightarrow m_{glass} = [\ ]\ kg$

Note: for any body: (Plate)

$$q_r = mCp\Delta T$$ → Required

$\Delta T = [\ ]\ [k/s]$

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* **for cylinder or sphere**

$$q_r = \dot{m} Cp \Delta T$$

$\dot{m}$: mass flow rate [kg/s]

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5 - sheet [5]

Properties of water

$\rho_w = 988\ kg/m^3$
$c_p = 4178\ J/kg\,k$
$\mu = 549.2 * 10^{-6}\ kg/m\,s$
$k = 0.648\ w/mk$
$Nu = 0.027 [Re]^{0.805} [Pr]^{1/3}$

$T_\infty = 25\ ^\circ C$
$D = 1.5\ Cm$
$V = 2\ m/s$
$t_s = 27\ ^\circ C$
$q_r = hA\Delta T = h\pi DL\Delta T$
$\therefore \dot{q}_r = \frac{q}{L} = h\pi D\Delta T = ?$

Solution: $Re = \frac{\rho VD}{\mu}$
$Pr = \frac{\mu c_p}{k}$

$\rightarrow \frac{hD}{k} = [\,] \Rightarrow h = w/m^2k$, $q = h\pi D\Delta T = [\,]\ watt$

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[9] - sheet [5] $\Rightarrow$ [Very Important] - [VIP]

Properties of Air

$k = 0.0267\ w/mk$
$\nu = 16 * 10^{-6}\ m^2/s$

$L_c = D = 0.025\ m$
$T_{air} = 30\ ^\circ C$, $t_s = 85\ ^\circ C$
$V = 2.5\ m/s$
$\rho = 0.0175 * 10^{-6}\ \Omega.m$
Required: $I = ?$, $h = ?$

[1] $Nu = 0.44 [Re]^{0.5}$ for $10 < Re < 10^3$

[2] $Nu = 0.22 [Re]^{0.6}$ for $10^3 < Re < 2 * 10^5$

Solution: $Re = \frac{VL_c}{\nu} = \frac{2.5 * 0.025}{16 * 10^{-6}} = [3906]$ [2] table

$\therefore Nu = 0.22 [Re]^{0.6}$

$\frac{hD}{k} = (0.22)(3906)^{0.6} = [\,] \Rightarrow h = [\,]\ w/m^2k$

$q_r = h\pi DL [T_s - T_{air}] = [145.068\ L]\ [watt]$

$\because q_r = I^2R$, $R = \frac{\rho . L}{\frac{\pi}{4} D^2}$

$\therefore 145.068\ L = I^2 \frac{\rho L}{\frac{\pi}{4} D^2}$

$\therefore \Rightarrow I = \sqrt{\frac{145.068 * \pi (0.025)^2}{4 * 0.0175}} = [\,]\ Amp$